Use of CAMx in Establishing Statewide Default $PM_{2.5}$ Background Concentrations

Purpose

Modeled fine particulate matter (PM2.5) concentrations produced by the Comprehensive Air Quality Model with Extensions (CAMx) model were used to identify an appropriate geographical delineation between background concentrations in the Western and Eastern portions of the state. The modeled PM2.5 concentrations were produced from an annual simulation covering the year 2007.

Model Inputs

CAMx is an Eulerian photochemical dispersion model that allows for integrated "one-atmosphere" assessments of gaseous and particulate air pollution over many scales ranging from sub-urban to continental. The CAMx modeling domain covered the Central and Eastern portions of the U.S., but emphasis was placed on grid cells over Iowa. The resolution of the domain was 12 km, which is much finer than the ambient air observation network. The annual simulation used the most recent model-ready emissions inventory available: the 2007 baseCv7 gridded emissions inventory produced by the Lake Michigan Air Directors Consortium (LADCO). Meteorological inputs were incorporated from the Weather Research and Forecasting (WRF) meteorological model and were generated as part of a previous regional collaborative effort with Virginia DEQ, North Carolina DENR, Maryland DE, New York SDEC, and the University of Maryland.

Methodology

The daily-averaged, speciated concentrations generated from CAMx data were processed at each grid cell to produce total PM2.5 concentrations in a form comparable to the metric used for the 24-hour and annual standards. The processing of the hourly CAMx output also included smoothing small-scale concentration features in the PM2.5 field that may mask important PM2.5 concentration gradients in the larger scale PM2.5 background field. The average of the highest 10% daily-averaged PM2.5 concentrations was chosen as a field representative of PM2.5 background concentrations to be compared to the 24-hour PM2.5 standard. A simple arithmetic mean of the daily PM2.5 concentrations across the entire annual simulation was selected to compare to the annual PM2.5 standard. Figure 1 and Figure 2 show the final analyzed PM2.5 concentration fields.

Annual CAMx output was spatially filtered so that only data in and around Iowa (extending 50 km beyond the border) remained, creating a sub-domain for this analysis. After review of the 24-hour and annual PM2.5 concentration fields, the annual average modeled PM2.5 concentrations were selected for use in this analysis because they better represent the PM2.5 background levels over a majority of the time period instead of only during specific events. Isolated PM2.5 “hot-spots” in the model output were undesirable for this analysis because the goal was to depict the PM2.5 background concentration gradient across the state without local influences. Hot spots in the CAMx results within the sub-domain were smoothed by calculating the average PM2.5 concentration within 50 km of each grid cell. The PM2.5 concentration at each grid cell was then reassigned to these calculated averages.

Comparison of the PM2.5 concentrations shown in Figure 1 and Figure 2 to monitored PM2.5 values revealed a significant overprediction of PM2.5 by CAMx. This bias is undesirable but determining the causes of these overpredictions requires a complex investigation beyond the scope of this analysis. In order to shift emphasis away from absolute values and towards the relative change in PM2.5 concentrations moving from west to east across the state the data were normalized. Regional modeling data are routinely used in a relative sense as an alternative to using the raw, absolute results of the model predictions. In this analysis the CAMx data were normalized by finding the range of the smoothed PM2.5 concentrations within the sub-domain, subtracting the minimum PM2.5 concentration within the sub-domain from the PM2.5 concentration at each grid cell, and then dividing that value at each grid cell by the range.

Application of this methodology resulted in normalized values within the sub-domain ranging from zero to one, as shown in Figure 3. The overall average of the smoothed and normalized data was then calculated (0.43) and used to divide the state into two parts by plotting a line across a map of the state connecting all areas with a concentration equal to the average. The dividing line for the average normalized concentration of 0.43 is depicted in Figure 3 by the roughly C-shaped solid black line. Where this line divided a county, that county was assigned to the portion of the state containing the greater portion of the county by area as calculated using Golden Software's "Surfer" graphing and mapping program. The resulting dividing line for eastern and western PM2.5 background values is depicted in Figure 3 by the pink line.

Default PM2.5 Background Values by County

The design values for all area-wide PM2.5 monitors in the eastern and western parts of the state were averaged to obtain a 24-hour and annual PM2.5 default background value for both areas. Two fence line monitors were excluded from this analysis (Clinton – Chancy Park and Davenport – Blackhawk Foundry). The 24-hour design values are the 3-year average of the 98th-percentile concentrations at each location. The annual design values are the 3-year average of the annual average concentrations. At locations where multiple monitors exist in close proximity (Cedar Rapids, Davenport, Des Moines, Muscatine and Waterloo) the average of the design values for each group was calculated first, then averaged with the remainder of the sites in the corresponding part of the state (Tables 1 and 2). The design values were obtained from the "Iowa Fine Particulate Monitoring Network Design Values 2009 – 2011" document available on the Department's ambient air monitoring technical documents website. The resulting 24-hour averages are 29 μg/m^3 for the eastern portion of the state, and 24 μg/m^3 for the western portion. The resulting annual averages are 10.9 μg/m^3 for the eastern portion of the state, and 9.7 μg/m^3 for the western portion (Figure 4).

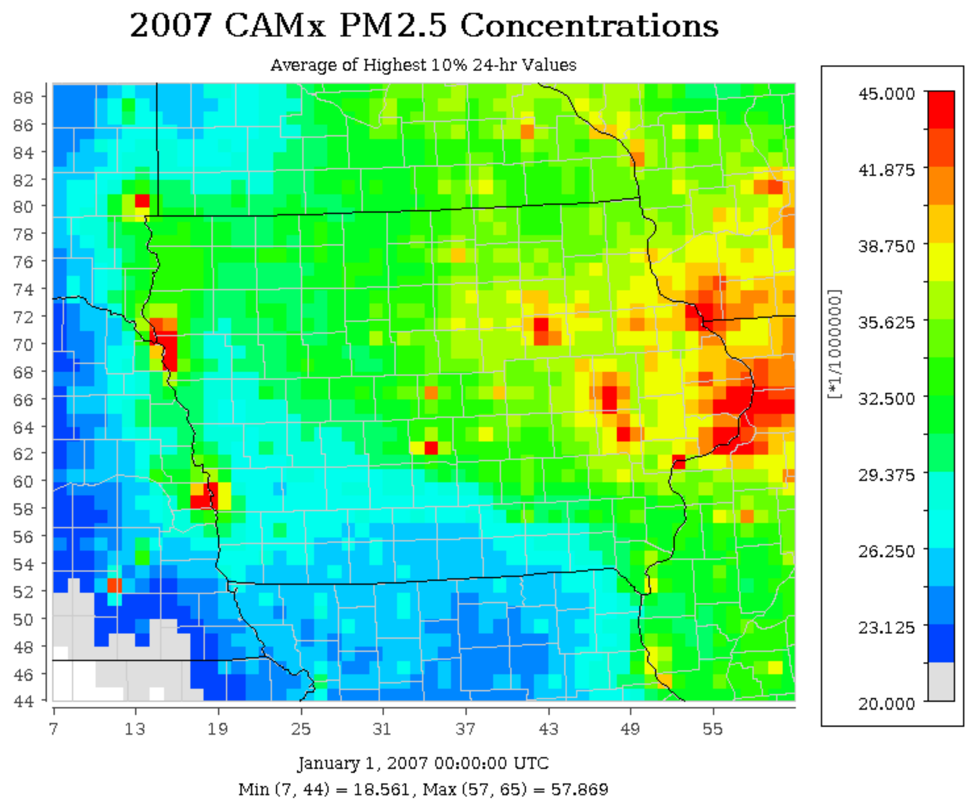

Figure 1. Average of the highest 10% daily PM2.5 concentrations (μg/m^3) for 2007 over Iowa.

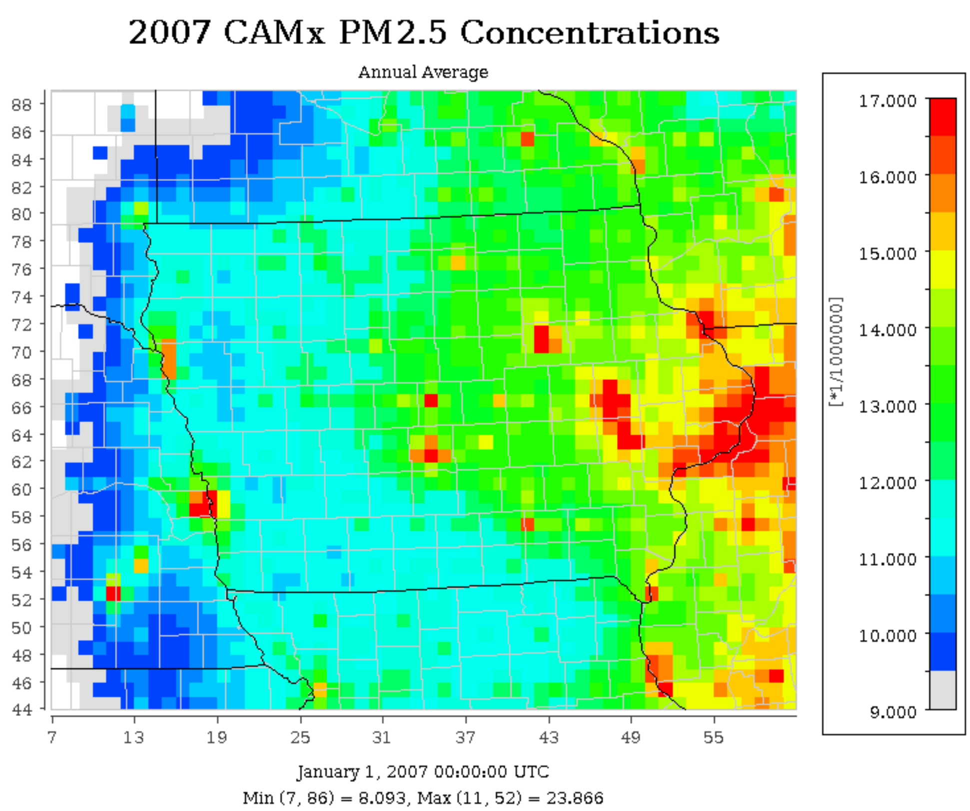

Figure 2. Annual average of daily PM2.5 concentrations (μg/m^3) for 2007 over Iowa.

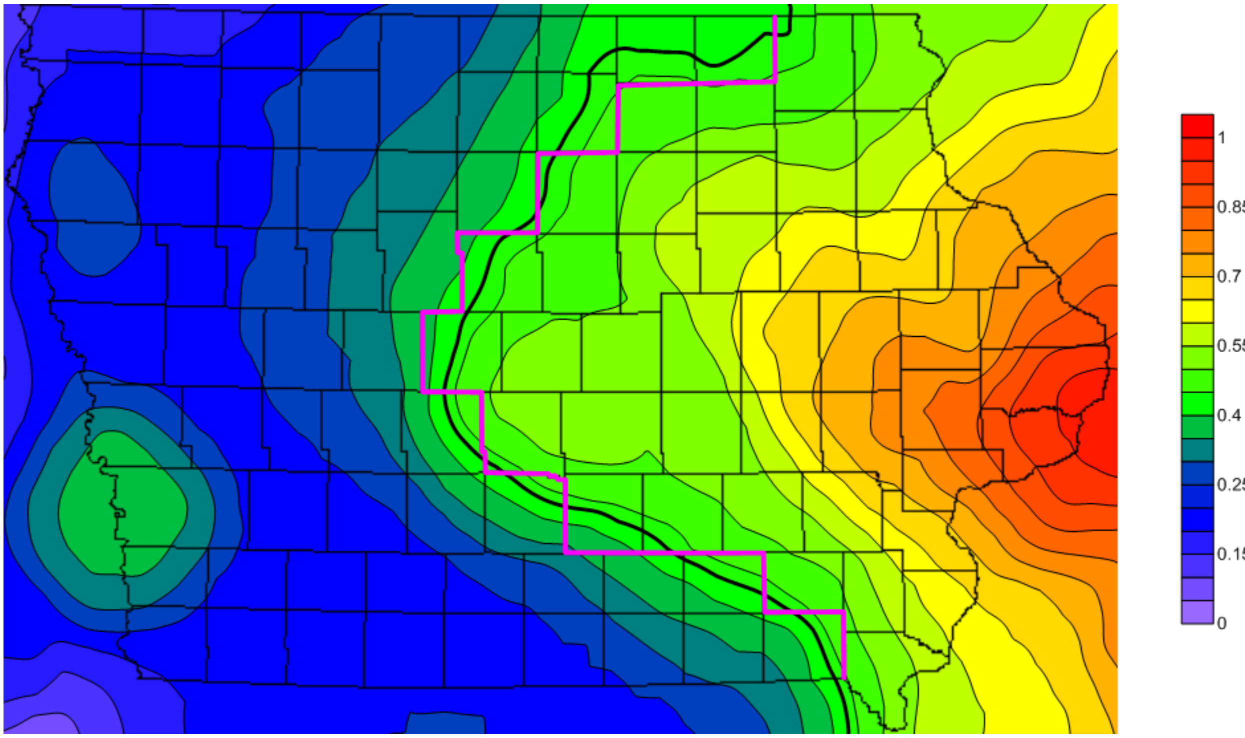

Figure 3. Smoothed and normalized annual-average PM2.5 concentrations for 2007 over Iowa.

Table 1. Eastern Iowa PM2.5 Background Calculations

City	Site Name	24-hour Design Value	24-hour Average	Annual Design Value	Annual Average
Cedar Rapids	Army Reserve	30	30	9.9	10.3
	Public Health	30		10.6	
Clinton	Rainbow Park	29	29	11.1	11.1
Davenport	Adams School	29	29	11.5	11.5
	Jefferson School	29		11.4	
Des Moines	Indian Hills Elementary (Clive)	27	27	9.6	9.7
	Public Health	26		9.7	
Iowa City	Hoover Elementary	28	28	10.8	10.8
Keokuk	Keokuk Fire Station	26	26	11.1	11.1
Muscatine	Franklin School	30	32	12.1	12.1
	Garfield Elementary	35		12.8	
	Greenwood Cemetery	30		11.3	

Waterloo	Grout Museum Water Tower	29 29	29	10.6 10.6	10.6
		Averages:	**29**		**10.9**

Table 2. Western Iowa PM2.5 Background Calculations

City	Site Name	24-hour Design Value	24-hour Average	Annual Design Value	Annual Average
Council Bluffs	Franklin Elementary	25	25	10.9	10.9
Emmetsburg	Iowa Lakes Community College	23	23	9.0	9.0
Keosauqua	Lake Sugema	25	25	9.6	9.6
Sioux City	Bryant School	27	27	9.7	9.7
Red Oak	Viking Lake	22	22	9.4	9.4
		Averages:	**24**		**9.7**

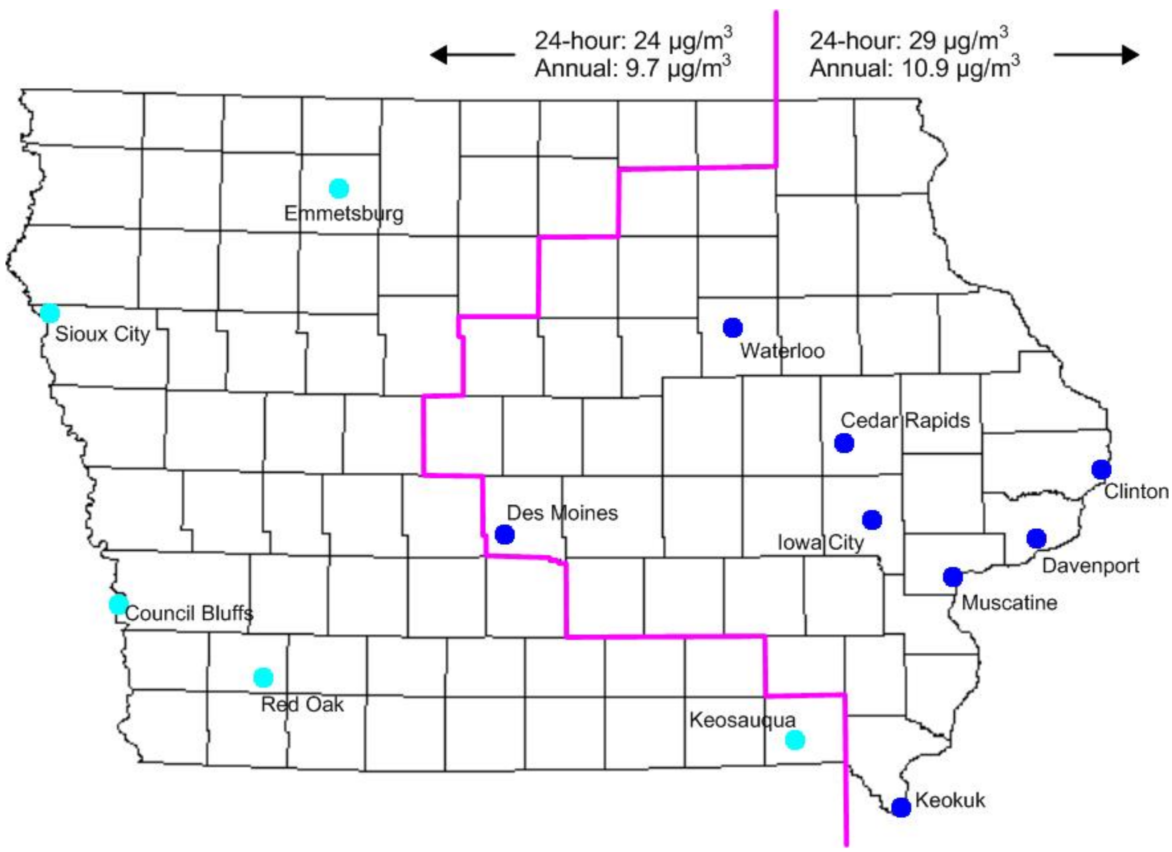

Figure 4. Monitors used in the calculation of the background PM2.5 concentrations.